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The Spruce Beetle

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Figure 1—*Yellowish orange and reddish colors in the tops of trees are evidence of spruce beetle infestation in Arizona.*

The spruce beetle, *Dendroctonus rufipennis* (Kirby), is the most significant natural mortality agent of mature spruce. Outbreaks of this beetle have caused extensive spruce mortality from Alaska to Arizona and have occurred in every forest with a large number of spruce-type trees. In North America the spruce beetle kills from 333 to 500 million board feet of spruce sawtimber annually, and in the last 25 years outbreaks have resulted in estimated losses of 300 million board feet in Alaska, 31 million in Idaho, 25 million in Montana, over 100 million in Arizona (fig. 1), and 3 billion in British Columbia.

Spruce beetle infestations create more extensive tree mortality in spruce stands. Outbreaks modify stand structure by (1) lowering the average diameter, tree height, and stand density; (2) changing species composition; and (3) leaving the

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smaller, slow-growing, and intermediate-sized trees to become the dominant.

Large outbreaks significantly reduce above-ground water evaporation and loss of water by transpiration due to massive loss of foliage. Extensive spruce mortality also significantly increases the water yield, resulting in increased amounts of rain and water in rivers, lakes, and streams.

As dominant spruce are killed, forage production increases. Although increased forage benefits some wildlife species, it adversely affects other species that depend on the mature spruce for habitat.

Hosts

The beetle infests all species of spruce within its geographic range (fig. 2). The more important commercial species of spruce attacked include white, Lutz, Sitka, and Engelmann.

Evidence of Infestation

On standing trees, the first sign of infestation is reddish-brown sawdust in bark crevices on the bole and on the ground around the base of the tree. Less noticeable signs are holes without sawdust in the bark and sawdust-clogged entrance holes. Masses of pitch may accumulate around the entrance holes. These

Figure 2—*The geographic range of the spruce beetle.*

signs are most visible the summer following infestation and become less noticeable months later.

Sawdust in bark crevices and on the ground directly below the stems is a sign of infestation on windthrown trees and residuals from logging. Spruce beetles are readily detected on the lower surfaces of downed trees, while *Ips* beetles are more common on the upper surfaces.

Some trees may be attacked on only one side of the bole, creating a "strip attack." The infested area may die; but the tree usually remains alive, so the foliage does not discolor. Trees with "strip attacks" frequently are infested by subsequent generations that attack the uninfested area, so the tree may host two or more generations of beetles simultaneously.

During the first fall and winter following infestation, one should look for trees "debarked" by woodpeckers (fig. 3). Partially debarked green trees are easily noticed from a distance in susceptible stands. However, on trees without significant debarking, one must be relatively close to see sawdust in bark crevices and around the tree base.

The needles of infested trees do not usually fade or discolor within the first year following attack. During the second summer, however, most needles turn yellowish. Some even remain green until the third summer, or up to 2 years after the initial infestation. The needles on different branches of the same tree discolor at different times. Needles periodically are washed from the trees by thunderstorms, leaving the upper crowns of exposed twigs with a yellowish orange to reddish hue.

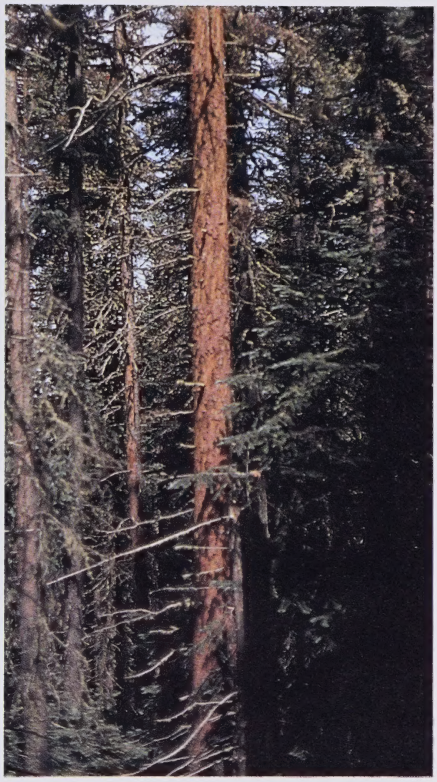

Figure 3—*Infested spruce debarked by woodpeckers.*

Identification of the Life Stages

Adult beetles are blackish brown to black with reddish-brown or black wing covers. The beetles are cylindrically shaped, approximately ¼ inch (4 to 7 mm) long, and ⅛ inch (3 mm) wide (fig. 4). Spruce beetles are the only beetles of this size, shape, and color attacking spruce in the Western United States.

In Alaska, Canada, and the Northeastern United States, another species of *Dendroctonus—D. punctatus* (LeConte), the Allegheny spruce beetle—also attacks spruce. The Allegheny spruce beetles may be distinguished from spruce beetles by their uniformly brown color.

Figure 4—*An adult spruce beetle.*

Spruce beetles look similar to other black *Dendroctonus* beetles and, if no host material is present, can by distinguished from them only by microscopic examination. Spruce beetles may also be confused, at first glance, with *Ips* beetles in spruce. It is important to remember that spruce beetles have the posterior margins of the wing covers evenly rounded, while *Ips* beetles have concave margins with teeth-like projections.

The eggs of the spruce beetle are oblong, pearly white, and 1/16 inch (1 to 2 mm) long. The larvae are stout, cylindrical, legless grubs that pass through four instars (the stages between molts during metamorphosis when larvae change into adults). The larvae attain a length of ¼ inch (6 mm) at maturity. The pupae are creamy white, inactive, and somewhat similar in size and shape to adults (fig. 5).

Life Cycle

The life cycle of the spruce beetle in the Rocky Mountains is generally 2 years. However, beetles may complete their life cycle in 1 year on warm sites at lower elevations or take up to 3 years in cool, well-shaded locations on north slopes.

In the 2-year life cycle, the adults may emerge anytime from May to October, depending on temperature. They attack host material soon after emerging. Adults appearing in August to October may represent a reemergence of parent adults or the movement of maturing brood adults to hibernation sites.

To deposit eggs, females bore through the outer bark and create egg galleries in tissue underneath the bark of the tree (fig. 6). Egg galleries are slightly wider than the beetle and packed with frass and boring dust, except for the terminal portion. Egg galleries may range from about 2.5 to 12 inches (13 cm). Eggs are usually

Figure 5—*A spruce beetle egg gallery.*

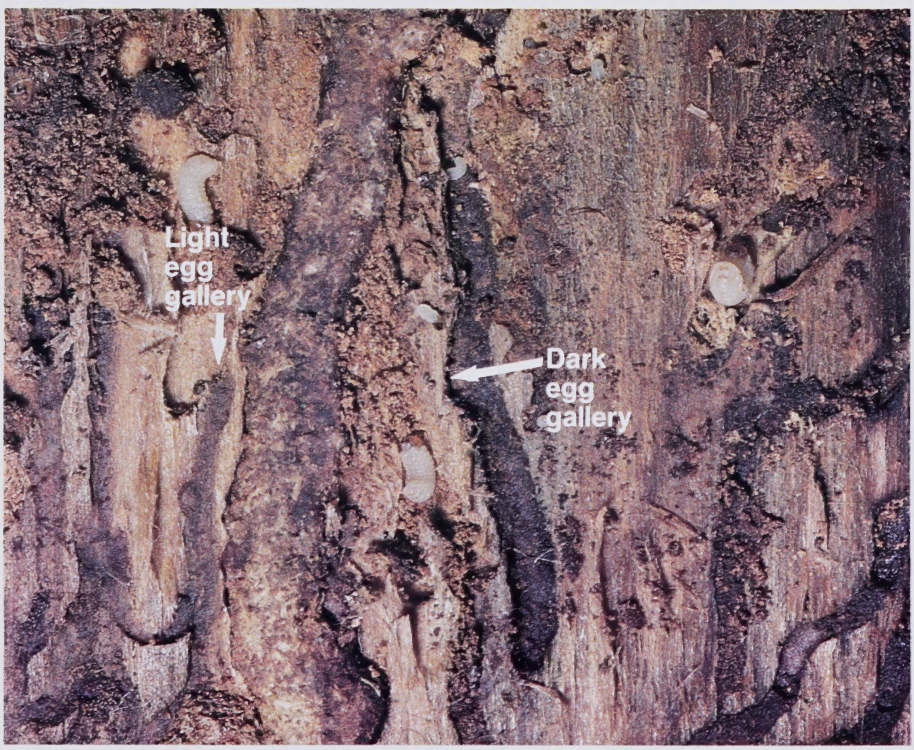

Figure 6—*Egg galleries.*

deposited in short rows along alternate sides of the gallery in numbers ranging from 4 to 14 eggs per centimeter of gallery.

After hatching, the larvae bore outward from the egg gallery, feeding as a group for the first and second instars. Third and fourth instars construct individual feeding galleries. The larval stage predominates during the first winter, although parent adults and eggs may also be present. During the 2-year life cycle, most larvae pupate approximately 1 year after the parents' attack. Pupation lasts 10 to 15 days and usually takes place in chambers at the end of the larval galleries.

During the second winter of the 2-year cycle, beetles may overwinter in their pupal sites or in the base of infested trees. In standing timber, anywhere from 5 to 88 percent of the adult spruce beetles emerge, move to the base of the tree, and bore into the bark near the litter line to hibernate. In downed material, most adults overwinter in place. The next summer, approximately 2 years after attack, adults emerge from both overwintering sites and attack new host material.

In Alaska, as in the Rocky Mountains, the life cycle of the spruce beetle takes 2 years in most stands. However, in stands on south-facing aspects or the upper side of downed trees, a 1-year life cycle is common.

In the Northeast and coastal areas of the Northwest, a 1-year life cycle may be more common. Adults emerge and attack from June through August, and the brood overwinters in the larval stage. The larvae resume development in May, transforming first to pupae, then to adults in June.

Stand Conditions Conducive To Infestations

Spruce beetles generally prefer downed spruce, and endemic populations usually are maintained in windthrown trees (fig. 7). When populations increase to high levels in downed trees, beetles may enter susceptible, large-diameter standing timber. Most outbreaks in standing timber originate in windthrown trees, although logging residuals, especially cull logs from logging areas, right-of-way lines, or seismic operations may be a contributing factor. Beetles may also be found in tops and stumps.

In mature stands, larger diameter ($\geq 18''$) trees usually are attacked first, but trees in all diameter classes may be killed. If an infestation persists in a stand, smaller diameter trees are killed along with the large trees. The diameter of standing trees is the only obvious characteristic indicating susceptibility. However, recent evidence from Alaska indicates diameter is important only when coupled with less-than-average radial growth in the preceding 5 years.

In the Rocky Mountain area, spruce stand susceptibility directly relates to its geographic location, tree diameter, basal area, and percentage of spruce in the canopy. Spruce stands are highly susceptible if they grow on well-drained sites in creek bottoms, have an average diameter (d.b.h.) of 16 inches or more, have a basal area greater than 150 square feet per acre, and have more than 65 percent spruce in the canopy.

In Alaska, the susceptibility of the spruce stand is based on average diameter, stand age, stand condition,

Figure 7—*Windthrown trees and logging residuals—prime habitats for beetle populations.*

and proportion of white spruce in the canopy. Stands of old-growth or damaged sawtimber, with an average diameter greater than 12 inches d.b.h. and composed of more than 70 percent white spruce, are highly susceptible if the larger diameter trees have a slower-than-average growth rate.

In British Columbia and the Northeast, the susceptibility of the spruce stand is based on characteristics used in the Rockies and Alaska, although the different characteristics are adjusted for local conditions.

Suppression Methods

Silvicultural, physical, and chemical methods are available to forest managers for reducing spruce beetle populations. Some options are suitable only for populations in downed host material; other options are better suited for infestations in standing trees. Most suppression methods are short-term responses to existing beetle populations and, therefore, correct only the immediate situation. Silvicultural treatments, though usually not considered a pure suppression method, have greater long-term effectiveness because they modify stand conditions.

Silvicultural Methods

- **Sanitation overstory removal** involves the removal of all infested and susceptible spruce to encourage regeneration of a new vigorous stand.

- **Sanitation partial cut** involves the removal of infested and susceptible spruce to improve the growth of the residual stand. The partial cut may approximate the step in a two-cut shelterwood regeneration system involving removal of

the crop in two successive cuttings-usually a seed cutting and a final cutting. Seed cutting is the removal of trees in a mature stand to provide for regeneration from seed trees retained for that purpose. If the residual spruce stand is below the recommended basal area (tree stems at breast height, or 4 feet 3 inches [1.30 m]), the trees may be uprooted in above-average windrisk situations.

- **Trap trees** are green trees with an average diameter (d.b.h.) greater than 18 inches that are felled before beetle flight occurs in order to capture a significant portion of the emerging population (fig. 8). Leaving the limbs on the trap tree keeps the bole from sinking into the ground and shades the bole from direct sunlight. If the bole is only partially limbed, the remaining limbs should shade the bole. Shaded trap trees will absorb more beetles.

In the past, the ratio of trap trees to infested standing trees has ranged from 1:2 to 1:10. Currently, the number of trees felled as trap trees varies with the size of the green trees to be felled as traps, with the number and size of infested trees, and with the existing beetle population. The extent of the infestation and the accessibility of the infested trees should determine where trap trees are placed, but the trap trees should encircle the infested trees.

Trap trees **must be removed** before the inhabiting brood emerges, or else the traps only serve to increase the population. Lethal traps, green trees injected with a silvicide and felled before beetle flight, are effective where traps cannot be removed.

Figure 8—*Green trees felled to capture emerging spruce beetles.*

Physical Methods

- Using **solar heat** involves exposing infested logging residuals or windthrow to direct sunlight to kill inhabiting beetles. To maximize brood mortality, buck the residuals into 5-foot lengths, remove all branches and debris shading the host material, and rotate the infested material at 2-week intervals during the summer to expose all surfaces. This treatment is effective in the Rocky Mountains but may not be effective in Alaska.
- Using **fire** involves piling and burning infested logging residuals and windthrow to destroy inhabiting brood. While the infested material is usually green and difficult to burn, only the bark has to be burned to destroy the brood.

Chemical Methods

- **Pheromones** (chemical substances that influence the behavior of insects and animals) increase the attractiveness of trap trees by attracting beetles into the trees or by discouraging infestation of high-value trees by repelling the beetles. Pheromones that aggregate or collect together in a mass are most efficient when used with trap trees. MCH, 3-methyl-2 cyclohexen-1-one, a pheromone that disperses or does not collect together in a mass, shows promise as a repellent; however, it has not yet been registered by the U.S. Environmental Protection Agency for use.
- **Insecticides,** such as lindane or carbaryl, are applied to either the boles of infested trees to kill adults when they emerge or to the boles of uninfested trees to kill adults during attack. In Alaska, carbaryl applied as a 2-percent spray has provided 100 percent protection from attacking beetles for at least 2 years. Cacodylic acid and MSMA can be injected into standing trees, which become lethal trap trees when they are felled.

Management Strategies

Forest managers can develop various strategies to reduce the loss of spruce stands to spruce beetle infestations. Before developing any strategy, the manager must determine the value of the resources, the accessibility, and the practicality of working with each stand, as well as the level of the beetle population. The level of the beetle population is important because the level dictates the type of strategy that will be implemented.

The primary strategy should be silvicultural treatment of potentially susceptible stands in order to maintain a healthy stand with a moderate growth rate. The first step in this strategy is to hazard-rate spruce stands. Hazard-rating will indicate the most susceptible stands. The stands can then be treated according to Alexander's (1986) guidelines, with harvesting directed at the most susceptible stands.

In high-value areas, such as campgrounds where cutting large spruce may be undesirable, protective sprays can be used to protect the standing spruce from emerging beetles in adjacent stands.

A single suppressive method or combination of methods may be used against infestations in standing trees or logging residuals that threaten residual stands. If a small number of standing trees becomes infested in an accessible area, then trap trees alone, trap trees enhanced with pheromones, or sanitation partial cuts may be cost effective. In larger infestations, however, sanitation overstory removal may be the best alternative. For infestations in inaccessible locations, trap trees are a viable option if the trees can be treated or removed before beetle flight; otherwise, lethal traps are an option.

For infested logging residuals and windthrown trees in cutting areas, solar heat, fire, or chemicals can be used. Infested logging residuals need never become a significant contributor to spruce beetle populations if stump height is kept below 18 inches (45 cm) and cull logs and tops are limbed, cut into short lengths and left unshaded, unpiled, and exposed to sunlight.

Assistance.

If you need more information about the management of the spruce beetle, consult your State Forester's office or Forest Pest Management, U.S. Department of Agriculture, Forest Service.

The publications listed in the references provide information on the biology, ecology, and management of the spruce beetle.

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Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

NOTE: Registrations of pesticides are under constant review by the Federal Protection Agency.
Use only pesticides that bear the EPA registration number and carry appropriate directions.